DOCUMENT RESUME

ED 326 031 EC 232 646

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TITLE What the Research Says about Computer-Based Instruction for America's Culturally and Linguistically Diverse Students.
PUB DATE Mar 90
NOTE 22p.; Paper presented at the Annual Conference of the Joint Center for Communication, Learning and Technology (2nd, New Orleans, LA, March 1990).
PUB TYPE Information Analyses (070) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Computer Software; Computer Software Development; Critical Thinking; *Cultural Differences; Elementary Secondary Education; Enrichment Activities; *Instructional Effectiveness; *Language Handicaps; *Teacher Role; Teaching Methods

ABSTRACT

This review of the literature on computer-based instruction for culturally and linguistically diverse students focuses on: (1) effectiveness of computer-assisted instruction; (2) its use in enhancement of traditional education; (3) its use as an expansion tool for critical thinking; and (4) the role of the teacher. The review concludes that the computer can be effectively used for instruction in a wide variety of ways, ranging from drill and practice for mastery of basic skills to interactive, multimedia simulations for exploring sophisticated concepts. Three suggestions are made on how to gain the maximum advantage from the computer's potential: teachers need to assume more direct responsibility for developing implementation strategies sensitive to the particulars of their classroom cultures; research regarding the implementation of computer-based education needs to move ahead rapidly; and software developers must use state-of-the art theories to create computer-based instructional programs sensitive to the wide range of needs and abilities of America's students. (38 references) (JDD)

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WHAT THE RESEARCH SAYS ABOUT COMPUTER-BASED INSTRUCTION FOR AMERICA'S CULTURALLY AND LINGUISTICALLY DIVERSE STUDENTS

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Paper prepared for presentation at the Second Annual Conference of the Joint Center for Communications, Learning and Technology, New Orleans, March 1990.

EC232646

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INTRODUCTION

Henry Becker, in his landmark 1983 national survey of computer use in America's public schools, found that schools in districts with a high percentage of minority families were much less likely to own microcomputers. Not only were students in these districts less likely to have access to a microcomputer in school (Becker, 1983-4), they were less likely to own their own computer at home (Martinez and Mead, 1988). Miura and Hess (1986) surveyed over 130 computer camps and summer classes and found that 91% of the students were described as Caucasian; only 2.5% were Black and 1% were Hispanic. When minority students did gain access to a microcomputer, they spent most of their time on drill-and-practice exercises (Becker, 1983-84) rather than on programming, simulations, advanced applications or other problem-solving activities.

This computer inequity has profound economic implications. Harlan Cleveland (1985) predicts that by the end of this century, approximately two-thirds of all work will be technology-based information work. Nine out of ten teachers, nationally, felt that "not having access to computers could put students from less affluent schools at a disadvantage" (Martinez and Mead, 1988). Miura and Hess (1986) suggest that "differences in the tendency to acquire

programming skills may be expected to increase gender and socio-ethnic inequities that now exist in the labor market" (p. 35). Yet Becker (1983-84) reports that there are clear differences between the use of computers in predominantly minority elementary schools and the use of computers in low SES predominantly White elementary schools where they "do programming with students much more often than they use their micros for drill work" (Issue No. 3, p. 7). Becker (1983-84) suggests that

> these contrasting patterns of use are indicative of two different philosophies regarding the appropriate role of today's microcomputer....some schools believe that by providing existing drill-and-practice software...to low-achieving students, they can be helped to catch up....Such schools are trusting that the properties that advocates of computer-based drill claim for their method...can be realized for the participating students. (Issue No. 3, p. 8)

Just how effective is computer-based drill-and-practice? How effective is computer-assisted instruction (CAI) in general? Does it warrant this "trust" placed in it by many school districts?

COMPUTER-ASSISTED INSTRUCTION: IS IT EFFECTIVE?

In 1975, Edwards et al. reviewed the CAI literature and concluded that traditional instruction supplemented by CAI is more effective than traditional instruction alone. Ten years later, Kulik and his associates (Kulik, Kulik, and Bangert-Drowns, 1985) conducted a meta-analysis of 175 studies of computer-based education effectiveness. They concluded that "CAI programs of drill and practice and

tutorial instruction almost always produced good results, raising student achievement scores in the typical case by 0.47 standard deviations" (p. 382) for elementary schools and that "CAI programs were moderately effective at both the high school and college level" (p. 383). In the intervening 10 years, many other researchers concluded that CAI was effective (Thomas, 1979; Burns and Bozeman, 1981; White, 1983; Malcom, 1984). By 1988, America's teachers "felt that the use of computers in the classroom has had a positive impact on American education" (Martinez and Mead, 1988). In the same year, the Office of Technology Assessment, Congress of the United States concluded that "CAI has been the most researched of the various interactive technologies. It has been demonstrated to be an effective supplement to traditional classroom instruction" (Office of Technology Assessment, 1988, p. 42).

After all of this, you would think that, as Hanley has suggested, "The effectiveness of CAI is a non-question" (cited in Neuman, 1989, p. 40). However, in 1988 Stan Pogrow, a leading educational researcher, wrote in a guest editorial for a major educational technology magazine: "The reality is that there is little evidence that current approaches to using computers enhance learning in measurable ways....Most of the effects from studies summarizing research on computers in education, such as those by Kulick [sic] and his associates at the University of Michigan, disappear at the secondary level when teacher effects are

controlled for" (p. 6). Actually, Kulik addressed this issue of instructor effects directly in an article published in 1985. Kulik concluded that "results from studies with and without a control for instructor effects were not significantly different in our most recent series of meta-analyses....the influence of a control for instructor effects was nonsignificant" (Kulik, Kulik, and Bangert-Drowns, 1985, p. 385).

Perhaps the real problem that Pogrow has with the CAI effectiveness literature is not a problem of methodology, but a problem of philosophy. As Pogrow writes elsewhere, "To some extent, the concern over the degree of structure in computer activities reflects the larger debate about direct instruction versus discovery learning" (Pogrow, 1989, p. 72). Direct instruction and discovery learning represent two different perspectives influencing the approaches to educational technology. This "larger debate" is referred to by the Office of Educational Research and Improvement, United States Department of Education as "...the debate between advocates of increasing uses of technology for enhancing traditional education and those who favor using technology as an expansion tool for critical thinking processes" (1989, p. iv).

COMPUTER-BASED INSTRUCTION: ENHANCEMENT OR EXPANSION TOOL

Enhancement of Traditional Education

One of the earliest CAI projects in the area of public school education was begun in 1963 under the direction of Patrick Suppes at the Institute of Mathematical Studies in the Social Sciences at Stanford University. The project was to develop CAI tutorials in initial reading and mathematics for "culturally disadvantaged" students (Suppes, Jerman, and Brian, 1968). By 1989, the Laboratory of Comparative Human Cognition concluded that "the manner in which computers are being employed in America's classrooms has caused the level and involvement with technology for women and minorities to decrease relative to Anglo/male norms" (Laboratory of Comparative Human Cognition, 1989, p. 74). As an example of this disparity, they cite a national survey of 1,082 schools using microcomputers in which it was found that "when computers are placed in schools for poor children they are used for rote drill and practice instead of the cognitive enrichment that they provide for middle-and upper-class students" (ibid., p. 74).

The belief that drill and practice CAI is effective for America's culturally and linguistically diverse learners is pervasive. Kulik, Bangert, and Williams (1983) found that "the effects of computer based teaching seemed especially clear in studies of disadvantaged and low aptitude students" (p. 25). Malcom (1984) states "research suggests that there have been real performance gains by minority students using

computer-assisted instructional techniques" (p. 20). Smith (1986) concluded that teaching methods that closely match the learning styles of learners from culturally diverse backgrounds include computer-assisted instruction, as well as role playing and socio-dramatic strategies, the use of a performance contract, and a tutoring plan. Guerrero and Swan (1988), in an assessment of the initial impact of computer-assisted instruction with the at-risk population in New York City, found that their results suggest that consistent use of any well-structured computer programs dedicated to mathematics and/or reading remediation benefits students in need of extra help.

However, Emihovich and Miller (1988) point out that "...most computer research utilizes a predominantly majority, middle-class population....there is a shortage of research with minority populations of all SES backgrounds" (p. 484). Hativa (1988) reports that relatively few CAI studies have "examined effects of CAI in relation to students' ability. For example, of the 28 CAI studies summarized by Kulik et al. (1985), only 5 compared high- and low-aptitude students. In their review of 35 studies that involved elementary school computer-based practice, Burns and Bozeman (1981) found only 13 that referred to students' abilities" (p. 367).

There are a number of reasons why it would be appropriate to assess CAI effectiveness relative to student characteristics. Emihovich and Miller (1988) found that

while the majority students significantly outperformed the minority students in the CAI condition, the minority students outperformed the majority students in the LOGO (a programming language) condition. Hativa (1988) found that low achievers working on a mathematics CAI program were more prone to commit errors unrelated to the knowledge of arithmetic than were high achievers. These errors were partly responsible for the ineffective CAI work produced by the low achievers. Furthermore, the effects of various CAI implementation strategies and content-material also may interact with student characteristics. Dalton, Hannifan and Hooper (1989) found that low-ability 8th grade males responded most favorably to individualized CAI instruction and least favorable to cooperative CAI instruction. Exactly the opposite preference was expressed by low-ability females who responded most favorable to the cooperative methods and least favorably to the individualized methods. Hativa (1988) expresses it most directly: "as long as a CAI system for individualized learning worked in a uniform mode for all students, there will always be students who benefit from some particular type of work while other students, with different aptitudes and styles of learning, will face problems working in that particular mode" (p. 395).

This lack of responsiveness to diverse students' styles is a characteristic of CAI drill and practice and tutorials. Gueulette (1982) reports, "Recent research has indicated that perhaps as much as one half of the population has the

sort of cognitive structure that resists acquisition of knowledge from the highly linear and orderly process of the computer...CAI programs may favor those learners who have the ability to quietly concentrate, pay attention to details, memorize facts, and stay with a single task until its completion. Extroverts (or perceptive learners), on the other hand, may not fare so well" (cited in Heermann, 1988, p. 5). In addition, Cardenas (1983) concluded that available CAI software is inappropriate, culturally and instructionally, for limited-English speaking populations. Cardenas (1983) reports that "a brief review of the emerging software indicates that, similar to the curriculum of the pre-equity era, it is a curriculum developed for White, Anglo-Saxon, English-speaking, middle-class children. The computer-assisted instructional programs make no attempt to bring about any compatibility between them and the characteristics of atypical student populations" (part I, p. 2).

Expansion Tool for Critical Thinking

An alternate approach to computer-based instruction is to use the computer as an expansion tool, such as Judah Schwartz' "intellectual mirrors" (Schwartz, 1989a), Mary Alice White's "tools of the mind" (White, 1986), programming languages such as LOGO and BASIC, and the use of computer applications such as word processing packages. More recent "expansion tool" uses include computer conferencing and database searches via telephone line and multi-media

applications such as hypermedia which can use computer-driven videodisc.

Computer competence is defined by some as the ability to program a computer to do what you want it to do (Martinez and Mead, 1988; Mecklenburger, 1986). Besides being able to control the computer, another reason that programming skill is considered important is the transfer of the problem solving skills learned in programming to other content areas. Clements and Nastasi (1988) observed 448 children working in pairs on the computer. Half the group had received 14 weeks of training in LOGO programming and half had received 14 weeks of training in drill and practice programs. They concluded that the LOGO group exhibited a significantly higher percentage of social behaviors important in problem-solving situations: conflict resolution, rule determination, and self-directed work. However, in his recent review of the relevant research, Crumb (1989) concluded that the belief that students who learn programming will simultaneously learn problem solving is "unsupported." "The hope that programming would develop thinking and reasoning skills was not realized" (p. 19). Crumb (1989) cites as evidence the results of a study by Pea, Kurland, and Hawkins (1985) in which they found that "programming produced little spontaneous transfer to problem solving" (p. 18).

An example of a successful application of the "expansion tool" concept is the HOTS (Higher Order Thinking

Skills) program developed out of the University of Arizona to teach thinking skills to Chapter 1 students. Pogrow (1989) reports that students "showed substantially greater gains on standardized tests when compared with the national average" (p. 47).

Another example of the "expansion tool" concept that has been shown to be successful with minority students is the use of simulations (Malcom, 1984). In his summary of the relevant research, Roblyer (1988) concluded that "science simulations seem to be even more effective than any applications in other content areas" (p. 88). Science simulations and microcomputer-based physical science laboratories help students overcome entrenched misconceptions regarding science concepts and principles (e.g., "You have more hot chocolate, so yours is hotter than mine.") (Office of Technology Assessment, 1988, p. 11).

The use of computers for telecommunications has also been shown to have particular advantages for minority students. The Laboratory of Comparative Human Cognition (1989) found that "students of Hispanic origin became excited and involved when they encountered material coming over the network in Spanish as well as English. These occasions provided a rare circumstance in which knowledge of Spanish was treated as a social advantage instead of a stigma" (p. 81). The result was that the students' language arts skills increased in both English and Spanish.

THE ROLE OF THE TEACHER

A number of researchers, task forces, national commissions, and national educational associations have advocated increased teacher training in the use of the new technologies in our nation's classrooms. Kepner (1986), in an article published by the National Education Association states that "as computer-based curriculum materials are entering the educational system, teachers must be trained to use them appropriately" (p. 47). Harvard University's Laboratory of Comparative Human Cognition also recognizes that "teacher training and systemic support are critical" (LaFrenz and Friedman, 1989) for the successful integration of computers into our schools. The National Task Force on Education recommends that: 1) school districts should collaborate with colleges to develop inservice teacher education programs in the applications of technology-based education; and 2) colleges should redesign pre-service teacher education to include effective uses of technology (Salser, 1987). A National Imperative: Educating for the 21st Century, published by the National School Boards Association (1988), asserts the "next President of the United States" should increase funding for preservice and inservice teacher training to prepare teachers to work with the technologies. The Office of Technology Assessment, Congress of the United States, in its influential book, Power On! New Tools for Teaching and Learning (1988)

asserts that "investments in technology cannot be fully effective unless teachers receive training and support" (p. 16).

Given the fact that so many diverse educational organizations and interest groups advocate teacher training in the use of technology, it would seem to be, as CAI effectiveness, an example of a "non-question." However, not everyone agrees. Morgan (1989) reports that "persuasive arguments have been made that investments in inservice teacher training do not affect student learning in the long term as much as the same level of investment in well-developed instructional materials and other teaching interventions" (p. 51). And again, as with the CAI effectiveness debate, this contradiction can be viewed as a piece of the "larger debate" between using technology to enhance traditional education or as an "expansion tool" for critical thinking.

Enhancing Traditional Education: The Teacher's Role

Some advocates of the use of technology to enhance traditional education speak of "teacherless instructional systems" (Winn, 1989, p. 44). The Laboratory of Comparative Human Cognition (1989) complains that "the thrust of current efforts [to develop stand-alone, computer-based educational activity systems] takes teaching out of the hands of teachers, thus representing a new attempt at creating the 'teacher-proof curriculum.'" (p. 84).

Don Smellie (1988), while president of the influential Association for Educational Communications & Technology (AECT), wrote:

> We are approaching a time when individuals entering the education profession will make a choice as to whether they pursue a career in what I will term, for the lack of better words, the "supply side" of education or pursue a career on the "delivery side" of education. p. 3.

For Smellie (1988), the role of the teacher is to diagnose, prescribe, guide, counsel and deal with people. "There will be less necessity to prepare teachers in content but more as managers of the learning process with a strong emphasis on utilization of well designed and validated learning resources" (p. 4).

Reigeluth (1989), a leading educational technologist, warns the profession that the:

> "new educational technologists" usually exhibit a total ignorance of and lack of interest in our considerable, well-validated knowledge base....Is it an image problem --that others perceive us to be machine-oriented, anti-human, and advocates of programmed instruction? (How many of us <u>are</u> still teaching or practicing programmed instruction?) Is it that we have failed to embrace a paradigm shift that has swept the world around us? Has our mindset become outdated? p. 68

How does the "new mindset" view the role of the teacher vis-a-vis technology in their classrooms?

Expansion Tools: The Teacher's Role

The "new educational technologists" see the teacher as more than a manager of instruction. Contrary to the view expressed by Smellie (1988) that it will be "less necessary to prepare teachers in content" (p. 4), using computers as expansion tools for critical thinking will require teachers to be deeply involved with and knowledgeable about the content they are teaching. The highly acclaimed Voyage of the Mimi Project (which utilizes a multi-media, inter-disciplinary approach) found that "prior experience with a microcomputer did not greatly affect software use, although the degree to which teachers themselves understood the mathematics and science concepts in the materials was highly influential" (McCarthy, 1989a, p. 48). Using the example of mathematics, Schwartz (1989) writes: "It is important to recognize that the mathematics we teach little kids is subtle. From this it follows that: The people who teach little kids mathematics should regard themselves, and should actually be, lifelong learners of the mathematics they teach" (p. 120).

This does not mean, however, that the "new mindset" advocates that the teachers "serve as ex cathedra authorities, nor is the authority of the text beyond question" (Schwartz, 1989, p. 57). Nor does it mean that the computer is beyond question. The very active role of the teacher in the development of children's critical thinking skills is clearly evident in the following

description of the use of a computer-based physical science simulation:

> Kirkpatrick found that most students at first completely trusted the data from the computer. It was Kirkpatrick's job to direct their attention, to help them become aware of sources of invalid data, to teach them to diagnose the causes and help them evaluate data the computer collected. He taught them to detect poorly calibrated probes, discard data from such probes, and to recalibrate their scientific instruments. He guided their discussion to confirm their understandings. (Office of Technology Assessment, 1988, p. 13).

CONCLUSIONS AND RECOMMENDATIONS

The computer can be effectively used for instruction in a wide variety of ways, ranging from drill and practice for mastery of basic skills to interactive, multimedia simulations for exploring sophisticated concepts and principles. Exclusive reliance on any one or two functions would be a disservice to our students. We do not need to choose between using computers to enhance traditional education and using computers as expansion tools for critical thinking. We can have our cake and eat it, too.

However, in order to gain the maximum advantage from the computer's potential, three things need to occur. First, teachers will need to assume more direct responsibility for developing implementation strategies which are sensitive to the particulars of their classroom cultures. Teachers need to be alert to possible "cultural mismatches" that can occur with technology transfer. Teachers need to be increasingly knowledgeable, not only

about technology and their students, but also about the content they are teaching. New forms of teaching and learning are evolving and teachers need to share their expertise and learn from others, including their own students. Teachers need to pay attention to ways their students interact with the computer and the computer programs. They need to be alert to the policies and procedures that may lead to computer inequities and work to change those that contribute to inequities. Given the fact that only 10% of the computer coordinators in our public schools are minority individuals (Martinez and Mead, 1988), technology education for America's minority teachers should be a priority.

Second, research regarding the implementation of computer-based education needs to move ahead rapidly. We do not need more "reviews of reviews" of the general effectiveness of CBI. We need to understand <u>how</u> and <u>why</u> CAI works and for <u>whom</u> and under <u>what</u> conditions. We need to recognize that there are negative effects to using computers for education and explore them. We need to know about possible "cultural mismatches," such as when the computer requires behaviors that are inconsistent with a student's preferences, experience, or values, or when the software doesn't correspond with the understandings and thought structures of a particular ethnic or linguistic group.

And finally, software developers must use state-of-the-art theories to create computer-based instructional programs and systems which are sensitive to the wide range of needs and abilities of America's students. Our schools are rich with diversity. We need instructional designers who have not buried their heads in the sands of time and space. We need software design that takes advantage of the fast-growing body of knowledge in the areas of cognitive learning theory, individual differences, and perception. Older, reductionist models based on research with populations of limited cultural and linguistic diversity will not suffice. Good design principles require that teams of professionals, including teachers, educational technologists, content experts and programmers, work together to develop the kinds of computer applications we need to properly educate ALL our students.

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